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INTRODUCTION

THE problem of maladjustment of population to resources in the island of Puerto Rico has stimulated, in recent years, many native as well as foreign observers to write on the population problem. An inspection of the extensive bibliography already accumulated, reveals that most of the observers have seen the population of Puerto Rico growing at a pace that suggested that this small island was really going to be an example of the population theories of Robert Malthus. It is interesting, however, to notice that although the island of Puerto Rico can boast of having relatively accurate data on population over a period of one hundred and seventy-five years, none of the students of whom the present writer has knowledge has attempted to describe the population growth of this island quantitatively to see whether it really fits in with the Malthusian theory.

Since Malthus was perhaps the first to handle the problem in a scientific manner, his theories regarding the growth of populations have considerable historical value. However, it has been observed in every

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country where population growth has been studied quantitatively, that his postulate of a constant rate of increase does not hold for any long period of time. Instead, the rate of growth decreases steadily with the flow of time, unless the conditions under which the population is growing are seriously altered. The logistic curve which postulates a dampened rate has proved a far more satisfactory description of population growth when tested against actual experience (Pearl, 1).

A quantitative study of population growth on the island of Puerto Rico is needed in order to establish what the pattern has been, what the prospects are for the future and whether this island should be considered an exception to the general experience in human population growth. Any such study leads us naturally to inquire about how the population has been affected by time changes in births, deaths, and migration and to the analysis of successive life tables in order to evaluate the changes in the mortality experience of the community.

The object of the present paper is, therefore, to present a quantitative description of the growth of the population of Puerto Rico and to analyze the dynamics involved as revealed by the island's records of vital statistics. For this purpose, we have found it convenient to divide the paper into two parts:

Part I. Analysis of population growth.

Part II. Time changes in the life tables for Puerto Rico.

PART I. ANALYSIS OF POPULATION GROWTH

During the Spanish regime, ten censuses of the population were taken in Puerto Rico at irregular intervals. The first of these censuses was taken in the year 1765, and the ninth, which was the last officially recorded, in the year 1887. The tenth census was taken in the year 1897, but apparently it was never made the subject of an official publication. In 1898, as a result of the Spanish-American War, the United States took possession of the island. The first census under the United States regime was taken in 1899 by the U. S. War Department. In 1910, the island of Puerto Rico was included in the decennial censuses of the United States, so that, from that date on, Puerto Rico had a census taken regularly at ten-year intervals. An additional census was taken in the year 1935 under the auspices of the Puerto Rico Reconstruction Administration.(2)

The population enumerated in each of the censuses taken from the year 1765 to the year 1940 is shown in Appendix Table I, an unofficial

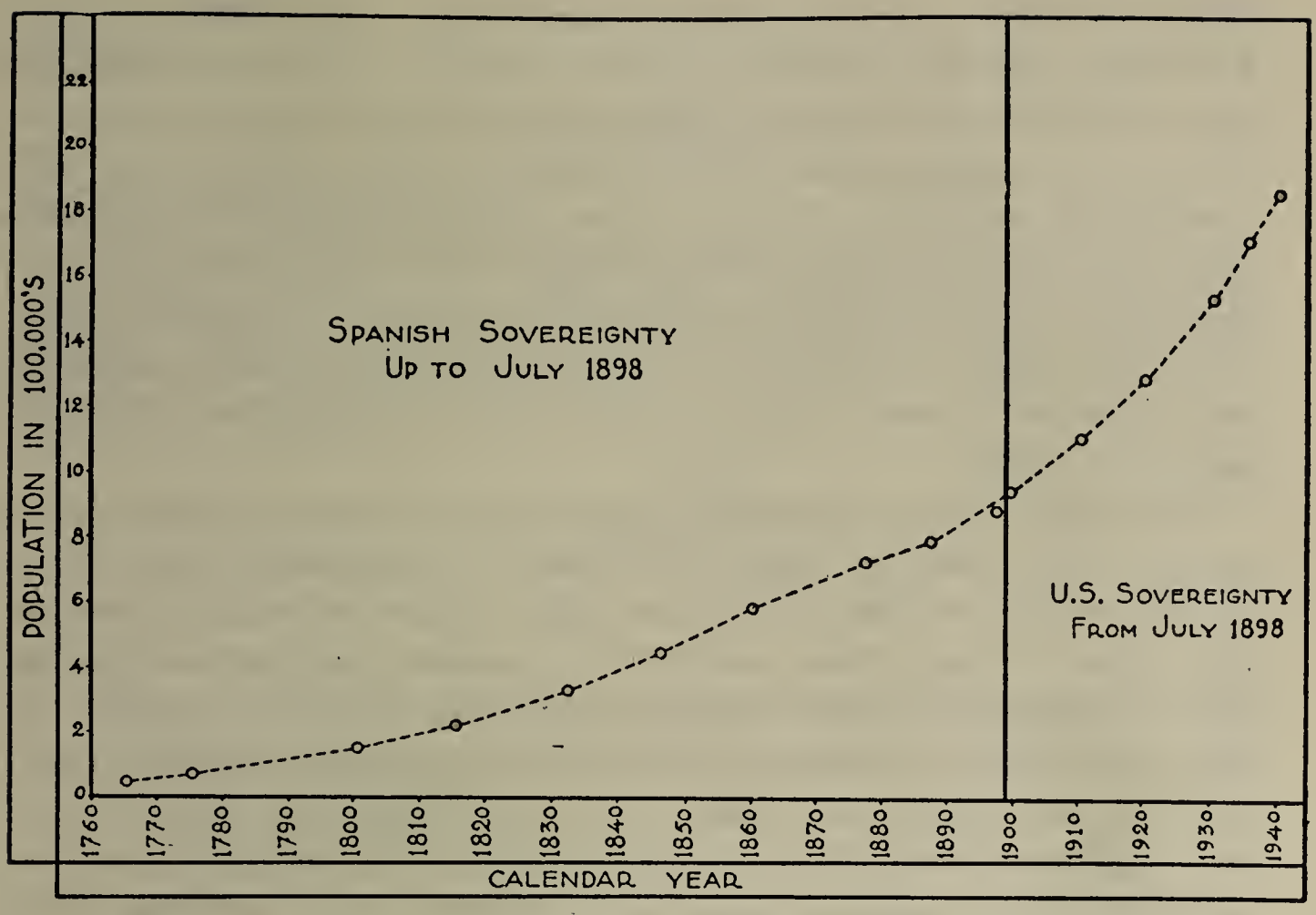

FIG. 1. ENUMERATED POPULATION OF PUERTO RICO, CENSUSES OF 1765 TO 1940

record of the 1897 census being included as a footnote. The average annual rate of increase during each intercensal period is also given, calculated by assuming that for these relatively short periods of time population growth proceeded at a constant rate. In this calculation and in the analysis of the population figures which follows, the value for 1897 has not been included, because it is not in the officially confirmed series. It will, however, be of interest to compare this unofficial count with the estimates made from the analysis of the other observations.

From a value of 4.61 per cent, corresponding to the intercensal period 1765-1775, the average annual rate of increase decreased steadily until it reached a value of 0.87 per cent in the intercensal period of 1877-1887. From then on, it increased from a value of 1.50 per cent during the intercensal period 1887-1899 to a value of 1.89 per cent for the period 1935-1940.

It is therefore evident that there have been two cycles of population growth in Puerto Rico, and that at least during the first cycle the population grew according to a decreasing annual rate of growth. This is clearly shown in Fig. 1, which plots the enumerated population of Puerto

Rico at the different censuses taken from the year 1765 to the year 1940. From this graph the following facts are evident: (1) the smoothness of flow of the lines connecting the points representing the enumerated population at each census, indicates that the censuses were probably taken with considerable accuracy; (2) the course of the points for the censuses taken from 1765 to 1887, inclusive, suggests that during this period the population of Puerto Rico may have been growing on a logistic curve; (3) a reactivation in the process of growth, appearing to start toward the end of the last century, initiated a second cycle of growth in the population of the island.

One might suspect the second cycle to have arisen as a result of the changes that necessarily must have followed the occupation of the island by the American forces in the year 1898. Under this assumption the high value of 1899 which creates the impression that the new growth cycle started prior to the American occupation, might be explained by better enumeration in the 1899 census, by immigration, or both. However, the last census taken during the Spanish regime in the year 1897, according to the historian Coll y Toste, quoted by Davis(3), showed the population of the island as made up of 890,956 souls, excluding 7,014 members of the army, 368 of the navy, and 1,101 prisoners. The position of the point representing this census in Fig. 1, indicates that the departure from the first cycle noted in the 1899 census, was present also in the 1897 census, and it appears that the transition to the second cycle of growth was probably during the period immediately preceding the occupation of the island by the forces of the United States, and not in the period following it. We shall therefore study the population growth in the following steps:

a. Describe the first cycle of growth of the island of Puerto Rico, using the censuses of 1765 to 1887;

b. Describe the second cycle of growth using the censuses of 1899 to 1940;

c. Investigate the factors underlying the second cycle in the growth of the island's population.

a. Description of growth: 1765-1887

As indicated earlier, the declining percentage increase in the succeeding intercensal periods suggested that a logistic curve might describe this first period of population growth on the island. In fitting the logistic

curve, the growth was considered as starting from zero, and the equation had the form:

$$y = \frac{K}{1+e^{a+bt}} \qquad (1)$$

where y is population at time t.

After a first approximation of the constants was made by the graphical method (4), the values were corrected by the least squares method of successive approximations, y deviations being minimized The final equation thus obtained was:

$$y = \frac{10.99}{1 + 6.536e^{-0.0330t}} \qquad (2)$$

where y represents population in hundred thousands and t time in years, measured from July 1, 1800.

Table 1 shows the observed population at each census taken during the period 1765-1887 as compared with the population calculated by sub-

TABLE 1

Population as enumerated and as calculated from the fitted logistic, Puerto Rico, 1765 to 1887

CENSUS DATE	POPULATION IN HUNDRED THOUSANDS		
	Observed	Calculated	Deviations: Obs.-Calc.
1765	.45	.50	—.05
1775	.70	.69	+.01
1800	1.55	1.46	+.09
1815	2.21	2.21	.00
1832	3.30	3.36	—.06
1846	4.48	4.52	—.04
1860	5.83	5.78	+.05
1877	7.32	7.26	+.06
1887	7.98	8.03	—.05

stituting the time of each census in equation (2). The exact dates of the censuses in this period are not known, and in the calculation they were assumed to be July 1.

It is evident from an inspection of the deviations, that equation (2) gives an excellent description of the observations. The standard deviation of the observed values about the curve is given by:

$$\sigma_{y\cdot x} = \sqrt{\frac{\Sigma\ (\text{dev.})^2}{\text{Degrees of freedom}}} = \sqrt{\frac{.0245}{9\text{-}3}} = \pm .064 \text{ hundred thousand, or 6,400 people}$$

A point of interest coming out of this description of the past censuses is that the inherent rate of growth of the population of Puerto Rico during this first cycle, 3.30 per cent per year, is almost identical with the corresponding rate, 3.22 per cent per year, determined for the population of the United States by Pearl, Reed and Kish (5). In other words, the populations of Puerto Rico and of the United States started their growth at almost the same rate.

If the population of Puerto Rico had continued undisturbed in its growth process according to the evidence afforded by this first cycle, it would have become stationary at an upper limit of 1,099,000 inhabitants, having attained half this growth by the year 1857. This would have given the island (area, 3400.6 square miles) a maximum density of population of 323 persons per square mile. Actually, according to the 1940 census the density was 550 persons per square mile and was still increasing. This departure from the growth process characteristic of the censuses of 1765 to 1887 will now be considered.

b. Description of growth: 1899-1940

The steady decrease in the annual rate of increase during the period 1765-1887, which suggested that the population could be described by a logistic curve, is not seen during the period 1899 to 1940 (Appendix Table I). The average annual rate of increase shows no tendency to slow down, except for the last intercensal period, 1935-1940, when the average annual rate of growth drops from 1.95 per cent in the preceding period of 1930-1935, to 1.89 per cent. It is possible, therefore, that a superficial inspection of this second cycle, without a retrospective look at past experience, might lead us to think that we are dealing with a Malthusian population, or even perhaps with an accelerated exponential growth. It should be noticed, however, that although this is a new cycle of growth, the average annual rate of increase is being measured relative to the lower asymptote of the first cycle, namely, the line $y = 0$. If we could make an estimate of the lower asymptote of this second

cycle, which theoretically represents the level from which the reactivation of the growth process producing this second cycle started, we could calculate the average annual rate of growth for the different intercensal periods involved, on a more rational basis.

A careful inspection of Fig. 1 suggests that the lower asymptote of this second curve must be a population in the neighborhood of 700,000. If for our purposes we consider that this is a satisfactory level from which to measure the average annual rate of increase in population during this second cycle, we should measure this relative increase exclusive of the base population of 700,000.

The results of this adjustment, shown in Appendix Table 2, give a decreasing average annual rate of growth from 4.93 per cent in the first intercensal period to 3.11 per cent in the last. This decrease suggests that the second cycle is growing in a way similar to the first and that we are justified in postulating a logistic curve for this period also. The level of this rate is a little higher than that of the first cycle, which creates the impression that the population is increasing now at an even faster rate than during the first cycle. It must be remembered however that by excluding the base population of 700,000 we segregated from our computations that group which theoretically was not contributing to the growth but was simply reproducing itself. This left us with a selected growing group as the only element of the population on which the growth rate is determined.

The equation of the logistic to be fitted to the population during this interval differs from that fitted to the first period of 1765-1887 in having an additive constant. This is due to the fact that in the first period the lower asymptote was the time axis. For the second period of growth, however, the lower asymptote (roughly estimated above as 700,000) is the line $y = d$, and the equation to be fitted to this interval will therefore be of the form:

$$y = d + \frac{K}{1 + e^{a+bt}} \tag{3}$$

where y is population at time t.

The constants were determined by a graphical procedure, advantage being taken of the logarithmic transformation of equation (3):

$$\log_e \frac{K - (y - d)}{y - d} = a + bt \tag{4}$$

The upper and lower asymptotes were first estimated by determining, by inspection, the values of K and d which gave the most satisfactory straight line when the function of the observed y values on the left hand side of equation (4) was plotted against time. The fact that for this second period of growth we have not yet accumulated enough evidence to obtain a good estimate for the upper asymptote, makes the problem of fitting difficult, but a first approximation to the logistic curve that fits the observations was obtained. Its equation is:

$$y = 6.5 + \frac{30}{1 + 8.544e^{-.0441t}} \qquad (5)$$

where y represents population in hundred thousands, and t time in years, measured from July 1, 1900.

Table 2 presents the observed population at each census taken during the period 1899 to 1940, and the population calculated as of the exact date of each census from equation (5).

TABLE 2

Population as enumerated and as calculated from the fitted logistic, Puerto Rico, 1899 to 1940

CENSUS DATE	POPULATION IN HUNDRED THOUSANDS		
	Observed	Calculated	Deviations: Obs.-Calc.
Nov. 10, 1899	9.53	9.565	—.035
Apr. 15, 1910	11.18	11.081	+.099
Jan. 1, 1920	13.00	13.001	—.001
Apr. 1, 1930	15.44	15.599	—.159
Dec. 1, 1935	17.24	17.249	+.009
Apr. 1, 1940	18.69	18.597	+.093

The deviations are seen to be small and accumulate to give a standard deviation:

$$\sigma_{y \cdot x} = \sqrt{\frac{\Sigma\ (\text{dev.})^2}{\text{Degrees of freedom}}} = \sqrt{\frac{.0450}{6\text{-}4}} = \pm 0.15 \text{ hundred thousand, or } 15{,}000 \text{ people}$$

Fitting by least squares was considered over-elaborate in view of the small number of observations, and the fitted curve may not be considered

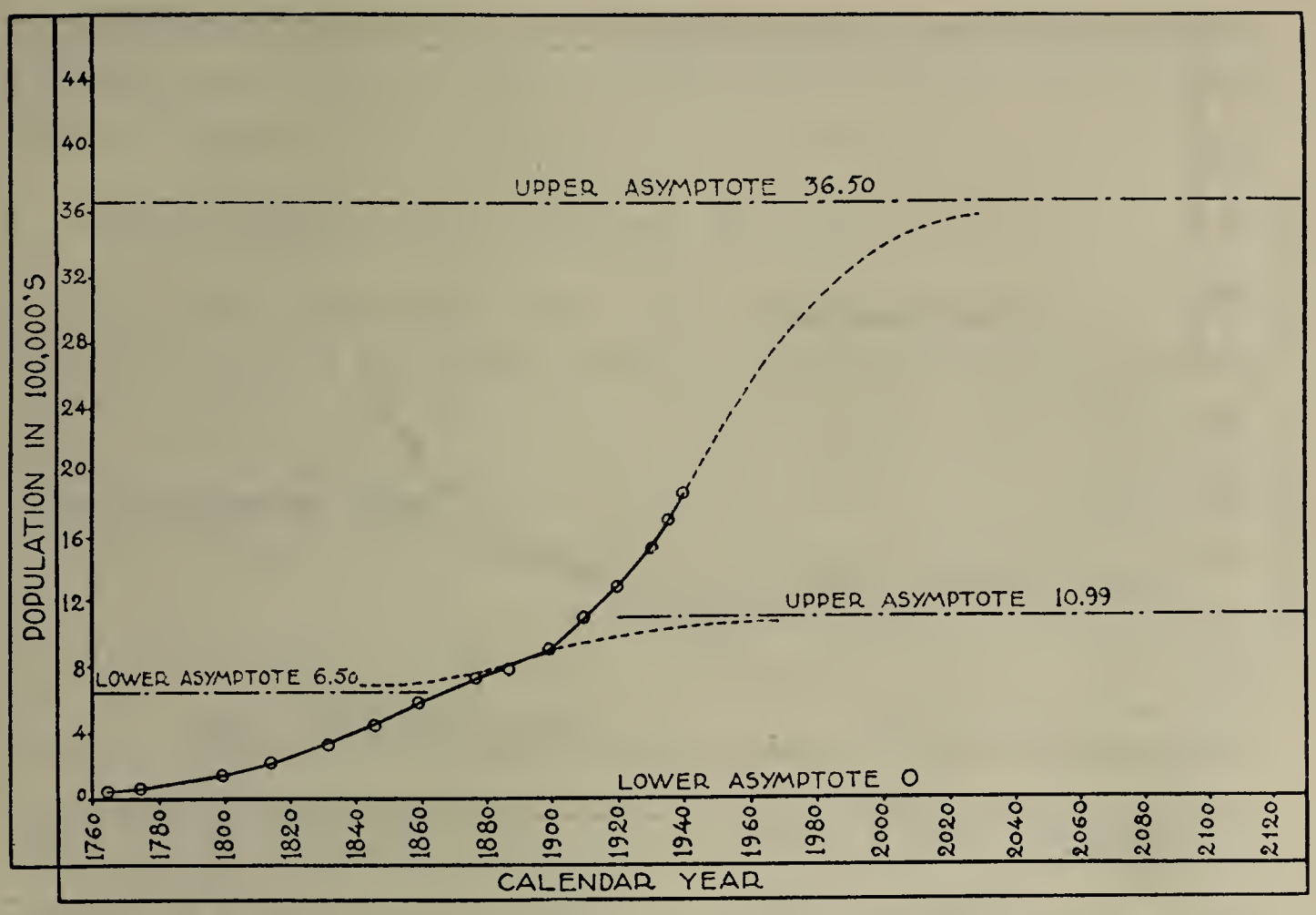

FIG. 2. THE POPULATION GROWTH OF PUERTO RICO FITTED WITH TWO SYMMETRICAL GROWTH CURVES

well enough established to warrant its use in long term predictions. When one or two more census counts are available it should be possible to estimate future growth with greater confidence. Nevertheless, the present curve furnishes a good description of the trend of growth over the past 40 years, and certain points of interest emerge.

The inherent rate of growth of the population in this second cycle is 4.41 per cent per year as compared to an inherent rate of growth of 3.30 per cent per year in its first cycle. However, it should be recalled that during the second cycle we have measured growth relative to a selected group of the population, which may account for the higher rate.

Although for the reasons stated above, the upper limit of growth is subject to a greater standard error, there is no doubt, from the evidence afforded by the observations, that the population in Puerto Rico is still far from attaining a stationary level and that our present population represents a point possibly not much more than halfway in the evolution of the second cycle. In other words, if the present growth of population on the island continues its course unaltered, we must expect our population to increase considerably with the flow of time.

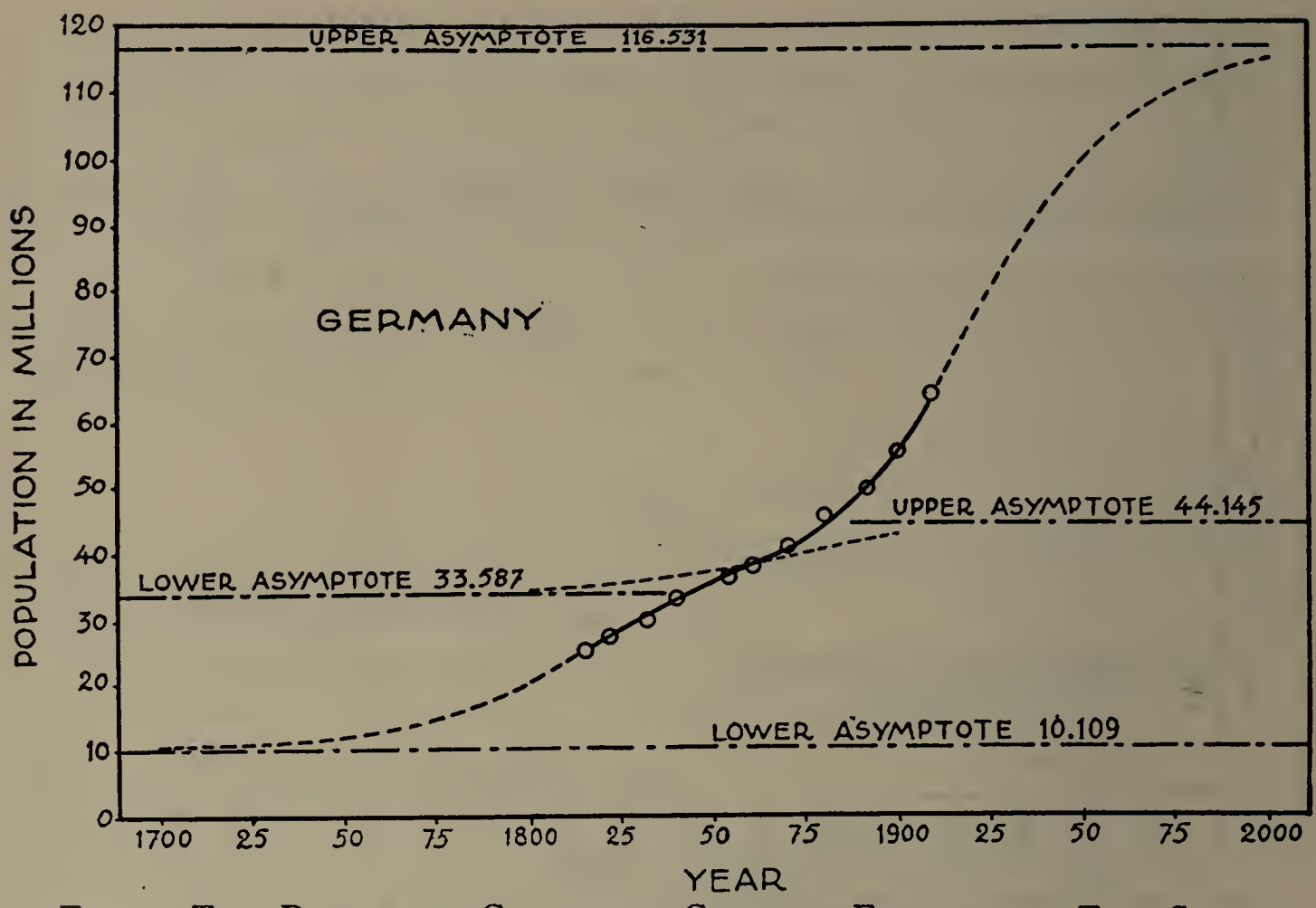

FIG. 3. THE POPULATION GROWTH OF GERMANY FITTED WITH TWO SYMMETRICAL GROWTH CURVES

This figure has been reproduced from *Studies in Human Biology* by Raymond Pearl, with the permission of Mrs. Pearl.

Fig. 2 shows the population growth of Puerto Rico fitted with the two logistic curves we have discussed above. The curves were welded by computing for each of the 12 years following the 1887 census, the weighted average of the two curves, using the second curve with the weight $t/12$ and the first with the weight $(12—t)/12$, where t is the number of years beyond 1887.

The cyclical character of population growth is not a new phenomenon in population studies. Pearl and Reed have stated that "in all countries of Europe certainly, the present epoch or cycle of population growth starts from a lower asymptote which represents the upper limit of the preceding cycle or epoch."(6) In most cases, however, the data available on population counts for these countries do not cover more than a single cycle of growth. In this respect, the case of Germany is an exception, and its data on the enumeration of its population at different dates reveal the transition from one cycle of growth to another. Fig. 3* shows,

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* Reproduced from *Studies in Human Biology* (1), p. 608.

for comparison with Fig. 2, the population growth of Germany fitted with two logistic curves by Pearl and Reed (6), and it is seen to give a strikingly similar picture to that of Puerto Rico.

c. Factors underlying the second cycle of growth

Every human population is in a state of constant change, since with the flow of time, it is suffering losses by deaths and emigration at the same time that it is being increased by births and immigration. The combined effect of these four processes is what makes it grow, decline, or remain stationary. It is therefore pertinent that in investigating the immediate causes of the reactivation of the process of population growth in the island of Puerto Rico, our first steps be directed to see whether there is any evidence about changes in the death, birth or migration rates that may account for it. As a matter of interest, before proceeding to do this, we present in Table 3 the population of Puerto Rico enumerated at each of the censuses taken from 1899 to 1940, as compared with the population that would have been expected at each of these censuses if the growth characteristic of the first cycle had continued.

TABLE 3

Population of Puerto Rico as enumerated 1899 to 1940, and as calculated from the logistic fitted to the observations of the period 1765 to 1887

CENSUS DATE	ENUMERATED POPULATION	CALCULATED POPULATION	EXCESS OF ENUMERATED OVER CALCULATED	
			Number	Per cent
Nov. 10, 1899	953 243	882 801	70 442	7.98
Apr. 15, 1910	1 118 012	936 591	181 421	19.37
Jan. 1, 1920	1 299 809	976 274	323 535	33.14
Apr. 1, 1930	1 543 913	1 008 736	535 177	53.05
Dec. 1, 1935	1 723 534	1 023 156	700 378	68.45
Apr. 1, 1940	1 869 255	1 032 708	836 547	81.00

The tremendous increase in population for the period 1899-1940 which is so evident from Table 3 has been explained by some of the most competent observers as a result of an increasing birth rate and a decreas-

ing death rate. From the excellent study of the problems of the island made in 1930 by the Brookings Institution, we quote:

> "This rapid growth [in population] is the combined result of an increased birth rate and a decreased death rate. The birth rate is almost twice that of the United States as a whole, and is steadily increasing. The death rate, on the other hand, has fallen from an annual average of 29.6 per thousand during the last ten years of the Spanish regime to 22.4 per thousand since 1925 . . . . . "(7)

The authors, however, base their assertion of an increasing birth rate on a superficial examination of the trend exhibited by the recorded birth rates of the island. They apparently overlook the fact that the registration of births in Puerto Rico during this period has been improving and that what appears to be an increase in the birth rate may be found to be, on further analysis, the result of more complete registration of births. We are forced to find some way of evaluating the birth rate which would eliminate the effect of changes in the completeness of registration. For this purpose we have made use of the following equation:

Increase in Population=Births—Deaths+Immigration—Emigration,

or transposing the terms,

$$\text{Births}=\text{Increase in Population}+\text{Deaths}-\text{Immigration}+\text{Emigration} \qquad (6)$$

Although the use of this equation for the evaluation of the birth rates may be open to criticism because of the possible incompleteness of death registration, we have reason to believe that in Puerto Rico, during the period under study, registration of deaths was sufficiently accurate to warrant the use of death statistics for this purpose. As soon as our system of vital statistics, which dates back to the year 1885, was centralized in the year 1931, we were admitted to the U. S. Death Registration Area, but not to the Birth Registration Area, which means that it was estimated that at least 90 per cent of the deaths, but not of the births, were registered at that time. Furthermore, the steady downward trend exhibited by our crude death rate during the course of the past forty years is just opposite to what we would expect if there were gross underregistration in the early years. Whoever is familiar with the customs and religious beliefs of the vast majority of our population, as well as with the accessibility of cemeteries, will have no difficulty in understanding the

relative accuracy of death registration in our island even prior to the enforcement of the law of 1931. There has undoubtedly been improvement in the registration of deaths of very young infants, but this would produce a small relative change in the entire number of deaths for all age groups.

Appendix Table 3 presents the reported births and deaths in the island of Puerto Rico from 1887 to 1940. Except for a few instances in which the death figures are exceptionally high, due to the effects of such calamities as major epidemics, hurricanes, etc., the number of annual deaths recorded shows a steady increase, in harmony with the increasing population. Although the number of annual births shows also a steady increase, this increase is out of all proportion to the increase in annual deaths. A close examination of the history of the registration system and enforcement shows clearly that registration of births has greatly improved during this period and that it would be unjustified to attempt to evaluate the change in birth rate from these figures.

The role of migration in the population growth of Puerto Rico during its second cycle can be considered negligible for all practical purposes, as can be seen from Appendix Table 4 which presents the balance of immigration to and emigration from the island, from the fiscal year 1908-09 to the fiscal year 1940-41. For the entire period of thirty-two years, the net loss was 53,714, and the largest net change in any single year was the loss of 8,729 in 1926-27.

The computation of the average annual births and birth rates for the different intercensal periods from 1899 to 1940, using the relationship between births, deaths, migration and increase in population expressed by equation (6) is given in Tables 4 and 5.

These tables bring out some facts of the utmost importance in understanding the dynamics of the processes that led to the increase in population initiating a second cycle of growth on an island whose natural resources were scarcely enough to support the stationary level approached during the first cycle of growth. These facts are:

1. The trend of the estimated birth rate has been almost stationary, with perhaps a small tendency in the direction of a decrease rather than an increase;
2. The birth rate expressed per 1000 female population of age 15-45 indicates that there has been no substantial change in the fertility of the island's female population;

TABLE 4

Computation of estimated average annual births from intercensal population increase, recorded deaths and migration, Puerto Rico, 1887-1940

INTERCENSAL INTERVAL	YEARS IN INTERVAL	POPULATION INCREASE DURING INTERVAL	DEATHS DURING INTERVAL	MIGRATION DURING INTERVAL	ESTIMATED BIRTHS DURING INTERVAL	ESTIMATED AVERAGE ANNUAL BIRTHS DURING INTERVAL
1887-1899	12.36	154 678	339 995	?	494 673	40 022
1899-1910	10.43	164 769	273 139	?	437 908	41 985
1910-1920	9.71	181 797	281 470	—10 415	473 682	48 783
1920-1930	10.25	244 104	322 258	—37 751	604 113	55 938
1930-1935	5.67	179 621	186 167	+ 4 835	360 953	63 660
1935-1940	4.33	145 721	149 500	—14 796	310 017	72 227

TABLE 5

Computation of estimated average annual birth rate and rate of natural increase, Puerto Rico, 1887-1940

INTERCENSAL INTERVAL	AVERAGE ANNUAL BIRTHS DURING INTERVAL		AVERAGE ANNUAL RECORDED DEATHS	AVERAGE INTERCENSAL POPULATION	ESTIMATED AVERAGE ANNUAL BIRTH RATE PER 1000	AVERAGE ANNUAL DEATH RATE PER 1000	ESTIMATED RATE OF NATURAL INCREASE PER 1000	AVERAGE INTERCENSAL FEMALE POPULATION AGE 15-45	ESTIMATED BIRTH RATE PER 1000 FEMALES AGE 15-45
	Recorded	Estimated							
1887-1899	24 750	40 022	27 508	875 904	45.7	31.4	14.3		
1899-1910	31 591	41 985	26 188	1 035 628	40.5	25.3	15.2	238 428	176.1
1910-1920	44 127	48 783	28 988	1 208 911	40.4	24.0	16.4	275 242	177.3
1920-1930	52 758	55 938	31 440	1 421 861	39.3	22.1	17.2	324 420	172.4
1930-1935	63 932	63 660	32 834	1 633 724	39.0	20.1	18.9	377 726	168.5
1935-1940	69 573	72 227	34 526	1 796 394	40.2	19.2	21.0	415 061	174.0

3. Migration has not contributed to the increase in population, for the balance is in favor of emigration and not of immigration;
4. The crude death rate in the island has shown a steady, uninterrupted decrease.

The above facts leave us with but one explanation for the reactivation of the process of growth of the island's population, and that is that it has been brought about by a decreasing death rate. (Evidence that this decrease represents a real change in mortality risks will be presented in the next section.) The implications of this assertion are very serious. It means that so far, the evolution of the island along the line of public health activities has far outstripped its evolution along the lines that are associated with a decreasing fertility, namely, socio-economic conditions, education, etc. Under these circumstances, public health activities are acting as a sort of boomerang against the welfare of the island. This does not mean at all that we should move backward and not forward in the movement toward a better civilization, by letting the death rate once more assume the proportions of times long past. It means that we should work to promote in every way possible, those measures that experience has shown will result in a substantial decrease in the fertility of the population. If the public health program proceeds on this broader basis, the course of the second cycle of growth may be substantially altered from that indicated at present, and a better balance between population and resources attained.

PART II. TIME CHANGES IN THE LIFE TABLES FOR PUERTO RICO, 1910 to 1940

The marked decrease in the crude death rate noted in the preceding discussion, requires further analysis before its implications are understood. It is a well-known fact that crude death rates are greatly affected by the age composition of the population. With age specific death rates remaining constant, a population may exhibit a decreasing crude death rate simply because its age composition has changed in such a way as to improve its general mortality experience, and it is therefore necessary to study the trend in mortality specific for age.

From the available statistical records, the average annual deaths by age groups for each three-year period centering around a census year were computed for the census years 1910 to 1940. It was impossible for us to obtain the necessary data to construct life tables for periods centering around censuses prior to that of 1910, and data specific for sex were

not available prior to the period centering at 1930. Life tables by race or color were left out of consideration because in our judgment the inaccuracies in reporting this item on the death certificates are too great to warrant their use.

Most mortality statistics by age groups for the island of Puerto Rico are given in the groups: under 1, 1 to 4, in 5-year groups from age 5 to 34, in 10-year groups from age 35 to 74, and in one single group from 75 years on, and abridged life tables based on these groupings were constructed. There were instances in which the age distribution did not conform to this pattern and deaths had to be redistributed in order to be consistent in the groupings and make the life tables comparable. In such instances the method of finite differences was used in splitting the central group of three consecutive groups of deaths of equal age intervals. Appendix Tables 5a to 5f show the raw data for the deaths, and the derived averages are shown in Appendix Tables 8 to 12.

The population by age, as of the day representing the center of each three-year period, was calculated by arithmetic interpolation between two consecutive censuses and by arithmetic extrapolation beyond the last census. Appendix Table 6 gives the enumerated population from which these estimates were made, and the estimated population is presented in the life tables (Appendix Tables 8 to 12).

For the construction of the abridged life tables we followed the method described by Reed and Merrell (8), taking advantage of the tables of the function ${}_nq_x$ which facilitate the computation of the probability of a person age x dying within the interval x to $x+n$ from the corresponding age specific death rate.

Every person familiar with the construction of life tables is well aware of the difficulties involved in the computation of the probability of dying during the first year of life, q_0. Our case was no exception to the rule. The method described by Dublin and Lotka (9) could not be used because the data needed were not obtainable. The equation for q_0 in terms of m_0 determined by Reed and Merrell (8), which aimed at a correction for the underenumeration of population in this age interval, was found convenient to describe the risk of dying during the first year of life in the life tables for the years 1934-36 and 1939-41, when Puerto Rico was included in the U. S. Death Registration Area. But prior to this the underregistration of deaths occurring during the first year of life was considerable and this equation underestimates the risk in such a case.

Examining all the evidence, we concluded that a better estimate of the probability of dying during the first year of life in the periods prior to that of 1934-36 was given by the average infant mortality for the period, which assumes that the error in the numerator of the fraction balances that in the denominator. Appendix Table 7 presents the data and computation for the average infant mortality for these periods.

With the values of ${}_nq_x$ determined, the survivorship to age x, l_x, and the deaths within the interval x to $x+n$, ${}_nd_x$, were immediately obtainable.

For the first ten years of life, the life table population, ${}_nL_x$, was computed from the formulas given by Reed and Merrell (8). Since the age intervals in the life table after age 10 were not uniform, the values of ${}_nL_x$ from this point on were determined by the procedure used by Greville (10), namely:

$$ {}_nL_x = {}_nd_x/{}_nm_x $$

For the final age interval of indefinite length, 75 years and over, this becomes:

$$ {}_\infty L_{75} = l_{75}/{}_\infty m_{75} $$

The expectation of life, $\mathring{e}_x$, was computed by the usual formula:

$$ \mathring{e}_x = T_x/l_x $$

where T_x is the sum of the life table population beyond age x.

Appendix Tables 8 to 12 present the data and the abridged tables from 1909-11 to 1939-41. A comparison of each life table function for all the tables brings out the real features of the time changes. The risks of dying in Puerto Rico have been decreasing steadily in all age groups, thus confirming the statement previously made that the decrease in the crude death rate experienced by our island in the course of the last decades has been the result of a decrease in the mortality risks of the community and not of a favorable change in the age composition of its population. For the thirty-year period the largest percentage decline (45 per cent) is for the age group 10-14, and this decreases with age to a 14 per cent decline for the age group 65-74. The effect of these decreasing mortality risks is perhaps more clearly seen in the survivorship to exact age x out of a group of 100,000 born alive, and in the expectation of life or average years of life remaining to survivors to age x, as these functions have changed throughout the course of the thirty-year interval covered by these tables. If the 100,000 live births were exposed throughout their lives to the mortality risks expressed by the life table for the

period 1909-11, before reaching their fifth birthday, they would have been reduced by death by more than 25 per cent, while if they had been exposed instead to the mortality risks expressed by the 1939-41 life tables, the reduction by death would not have reached the 25 per cent level until after their fifteenth birthday. Furthermore, the expectation of life at birth, for both sexes, has been increased by over seven years during this thirty-year period. In other words, the average person born and living throughout his life under present conditions might expect to live over seven years more than the average person who was born and lived his life exposed to the mortality risks prevailing on the island during the period 1909-11.

However, in spite of the improvement in the health conditions of the island suggested by these time changes, we must face the challenge of other countries in evaluating our achievements. Although the expectation of life increased substantially in Puerto Rico during the thirty years elapsed between 1910 and 1940, much still must be done in order to approach the level attained by the white population of continental United States (11), which had in 1940 an expectation of life at birth eighteen years greater for the males and twenty years greater for the females than the corresponding groups for Puerto Rico. Even the colored population of the United States had an expectation of life at birth eight years greater than the Puerto Rican population in 1940.

A more complete picture of the situation may be had by looking at Fig. 4, which presents for comparison, the survivorship curves plotted from the following life tables:

(1) Puerto Rico, all classes, 1909-11;
(2) Puerto Rico, males and females, 1939-41;
(3) United States, white males and females, and colored males and females, 1939-41.

Many interesting facts are disclosed by this graph. First, it offers very good evidence of the improvement in the health conditions of the island that has taken place in recent years. At the same time, it shows us the further improvement necessary to bring our specific death rates down to the level attained in one of the more advanced countries. It clearly points out that the greatest concern in our efforts to promote better health conditions in our island should be with the population in the younger age groups, i. e., infancy and childhood. According to this graph, if we could follow throughout their lives groups of 100,000 babies born alive at the same time, and dying off according to the 1939-41 risks,

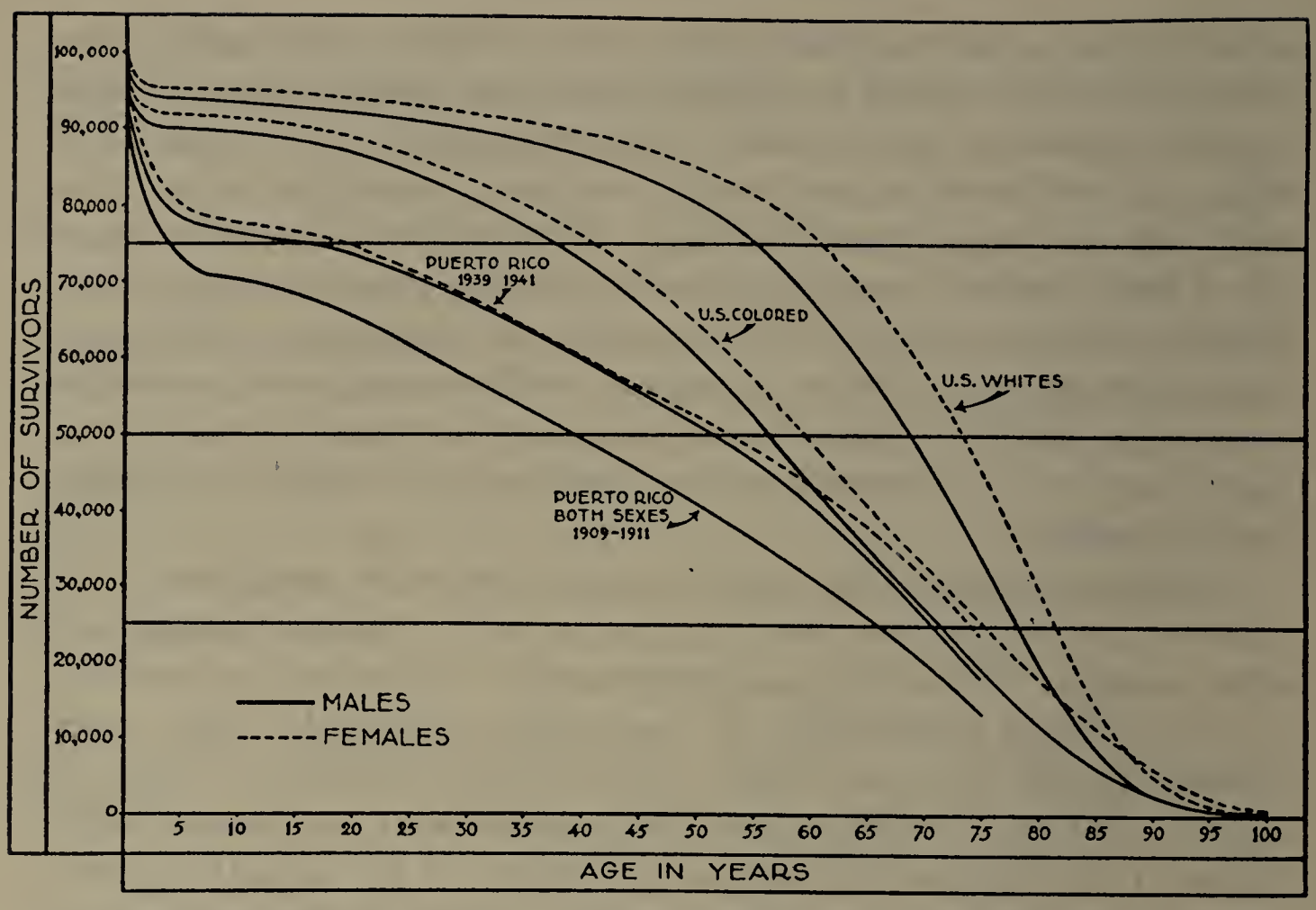

FIG. 4. NUMBER OF SURVIVORS OUT OF 100,000 BORN ALIVE: PUERTO RICO, 1939-1941 AND 1909-1911; UNITED STATES, 1939-1941.

in the island of Puerto Rico and in continental United States, we would find that in Puerto Rico, by its fifth year of life, the group would have been reduced by death more than 20 per cent, while in the United States the group of white babies would have been reduced by only 5 per cent, and that of colored babies by 9 per cent. While in the United States, a little over 75 per cent of the original 100,000 live births would be still alive at age 60 if they were white females, at 55 if white males, at 40 if colored females, and at 37 if colored males, in Puerto Rico, in both the male and the female groups, the age at which 75 per cent would still be alive and 25 per cent dead, would be reached shortly after the group had celebrated its fifteenth birthday.

One more interesting fact brought out by Fig. 4 is that in Puerto Rico, sex differentials in mortality are not as pronounced as in continental United States. The reason for this, in our judgment, should be sought for in a study of the most important causes of death in the island. Such a study is already in progress.

SUMMARY

This paper has presented an analysis of population growth in Puerto Rico and the relation of this growth to time changes in the vital statistics of the island. The observations on which this study is based cover the period between the first official census of the island, taken during the Spanish regime in the year 1765, and the last official census taken in the year 1940 under the United States regime.

During this period the population growth of the island presents definite evidence of two cycles. The first, already in progress by the year 1765, shows at some time during the period 1887 to 1897, a transition to a second cycle, which at present is still in progress.

An analysis of the first cycle showed that the observations for this period could be fitted very satisfactorily by a logistic curve of the type so extensively used to describe the growth of populations. The equation of this curve indicated that the population of Puerto Rico started to grow at an annual rate of 3.3 per cent, which is practically the same as the rate at which the population of continental United States started its growth process. The rate of growth decreased steadily, and the population of the island was apparently approaching a limit of about 1,100,000 inhabitants prior to the changes which initiated a new wave of growth.

A superficial inspection of the second cycle of growth suggested the possibility that during this period the population has been growing at a nearly constant rate, as postulated by the Malthusian theory, but a more critical analysis revealed good reason to believe that we were dealing here with another logistic curve in its first phases of growth. A curve of this type was, therefore, fitted to the observations and found to give a good description of them. However, due to the small number of observations accumulated during this second phase, the equation of the fitted logistic should not be used in long term predictions of population, until in the light of new evidence it can be properly revised. The inherent rate of growth obtained from this equation for the second cycle is 4.4 per cent per year. This rate may be expected to decrease steadily with time unless the conditions under which the population is growing at present are seriously disturbed.

An inquiry as to the factors that influenced the population growth of the island to the extent of producing a second cycle showed that we must attribute the whole thing to a steadily declining death rate while the birth rate remained virtually stationary.

To examine the changes in mortality more completely, life tables were constructed for as far back as reliable data were available. From these life tables, covering the period 1910 to 1940, we can clearly see how mortality risks in Puerto Rico have steadily declined in all age groups. This decrease has manifested itself in an increase in the expectation of life at birth from 38.4 years in 1910 to 46.0 years in 1940. Nevertheless, there is still much to be done in the realm of public health if we want our mortality risks to compare favorably with those of the more advanced countries. A better idea of the tasks ahead may be had if we realize that in the year 1940 the expectation of life at birth of the white population of the United States exceeded ours by about 20 years.

As the sole factor responsible for the new growth wave, which has created so many problems of maladjustment of population to resources, has been found to be a steadily decreasing death rate and an almost stationary high birth rate, we must conclude that the development in those factors affecting the fertility of our people, such as education, and standard of living, has not kept pace with the progress made by the public health activities directed at a reduction in death rates. If further improvement in the death rate is not to result in still more serious problems associated with over-population, there must be a decrease in the fertility rate as well. This means that the various agencies concerned with the welfare of the island should focus their attention on ways to bring this about and not concentrate solely on efforts to reduce mortality.

BIBLIOGRAPHY

1. Pearl, R. Studies in Human Biology, Chapters XXI, XXIV, and XXV. Williams and Wilkins, *Baltimore,* 1924.
2. Truesdell, L. E. The Population Census of Puerto Rico. *Estadistica—Journal of the Inter-American Statistical Institute,* 1: No. 3, 26-32, September, 1943.
3. Davis, Brigadier General George W., U. S. V. Report on Civil Affairs of Puerto Rico, 1899, p. 158. Government Printing Office, *Washington, D. C.,* 1900.
4. Pearl, R. Medical Biometry and Statistics, Chapter XVIII, Third Edition, Revised and Enlarged. W. B. Saunders, *Philadelphia,* 1940.
5. Pearl, R., Reed, L. J. and Kish, J. F. The Logistic Curve and the Census Count of 1940. *Science,* 92; 486-488, November 22, 1940.
6. Pearl, R., and Reed, L. J. The Growth of Human Population, from *Studies in Human Biology,* by Pearl, R., Chapter XXV, p. 588. William and Wilkins, *Baltimore,* 1924.
7. Clark, V. S., *et al.* Puerto Rico and Its Problems, Introduction and Summary

of Recommendations, p. xxiv. The Brookings Institution, *Washington, D. C.*, 1930.

8. Reed, L. J. and Merrell, M. A Short Method for Constructing an Abridged Life Table. *American Journal of Hygiene,* 30A: 33-62, September, 1939.
9. Dublin, L. I., and Lotka, A. J. Length of Life, Chapter XIV. Ronald Press Co., *New York,* 1936.
10. Greville, T. N. E. Short Methods of Constructing Abridged Life Tables. *The Record, American Institute of Actuaries,* Vol. 32, Part 1, No. 65, June, 1943.
11. Bureau of the Census. United States Life Tables 1939-1941. *Vital Statistics Special Reports,* 19; No. 4, 33-45, January 11, 1944. Bureau of the Census, *Washington, D. C.*

APPENDIX

APPENDIX TABLE 1

Population of Puerto Rico and annual rate of increase during each intercensal period: 1765 to 1940[1]

CENSUS DATE	POPULATION ALL CLASSES	ANNUAL RATE OF INCREASE (PER CENT)
1765	44 883	—
1775	70 250	4.61
1800	155 426	3.20
1815	220 892	2.34
1832	330 051	2.42
1846	447 914	2.17
1860	583 308	1.92
1877	731 648	1.32
1887	798 565	.87
Nov. 10, 1899	953 243	1.50
Apr. 15, 1910	1 118 012	1.54
Jan. 1, 1920	1 299 809	1.56
Apr. 1, 1930	1 543 913	1.69
Dec. 1, 1935	1 723 534	1.95
Apr. 1, 1940	1 869 255	1.89

Note: The population enumerated by the census of 1897 quoted from an unofficial source is given as: 890,956 souls, excluding 7,014 members of the army, 368 of the navy, and 1,101 prisoners. See reference (3).

[1] Data for the censuses taken under the Spanish regime from 1765 to 1887 inclusive, obtained from the War Department, Office Director Census of Porto Rico — Report on the Census of Porto Rico, 1899, page 40. Government Printing Office, *Washington,* 1900. Data for the censuses taken during the U. S. regime obtained from the official releases of the U. S. Census Bureau.

APPENDIX TABLE 2

Annual rate of growth for each intercensal period from 1899 to 1940 of the population in excess of 700,000 persons in Puerto Rico

CENSUS DATE	POPULATION IN 100,000's	POPULATION IN 100,000's IN EXCESS OF 7.00	INTERCENSAL PERCENTAGE INCREASE OF POPULATION IN EXCESS OF 7.00	LENGTH OF INTERCENSAL INTERVAL IN YEARS	ANNUAL PERCENTAGE INCREASE OF POPULATION IN EXCESS OF 7.00
Nov. 10, 1899	9.53	2.53			
Apr. 15, 1910	11.18	4.18	65.217	10.43	4.93
Jan. 1, 1920	13.00	6.00	43.540	9.71	3.79
Apr. 1, 1930	15.44	8.44	40.666	10.25	3.39
Dec. 1, 1935	17.24	10.24	21.327	5.67	3.47
Apr. 1, 1940	18.69	11.69	14.160	4.33	3.11

APPENDIX TABLE 3

Reported[1] annual births and deaths in Puerto Rico, 1887 to 1940

YEAR	DEATHS[2]	BIRTHS[2]	YEAR	DEATHS[2]	BIRTHS[2]
1887	?	?	1914	22 343	47 578
1888	25 568	27 401	1915	25 115	45 268
1889	26 255	25 113	1916	29 491	43 360
1890	26 955	24 231	1917	38 675	44 396
1891	24 089	23 496	1918	39 299	52 003
1892	24 474	25 302	1919	30 570	46 285
1893	21 616	25 457	1920	29 918	50 416
1894	24 896	24 548	1921	30 015	51 190
1895	26 284	25 090	1922	29 666	50 830
1896	25 435	26 270	1923	27 143	51 162
1897	31 980	25 827	1924	27 332	53 876
1898	33 614	19 719	1925	33 519	53 059
1898-9	39 918	?	1926	32 946	56 675
1899-1900	44 023	?	1927	30 500	50 746
1900-1	35 800	19 930	1928	35 467	56 708
1901-2	24 500	25 898	1929	38 534	52 468
1902-3	25 553	30 123	1930	28 870	54 574
1903-4	23 100	40 053	1931	32 146	65 700
1904-5	23 700	28 472	1932	35 610	66 436
1905-6	21 100	32 226	1933	36 763	61 655
1906-7	27 125	34 778	1934	31 703	65 595
1907-8	23 500	34 701	1935	30 753	67 585
1908-9	22 000	38 105	1936	34 788	68 962
1909	22 274	37 444	1937	37 132	67 919
1910	26 675	37 706	1938	33 870	69 823
1911	26 579	39 106	1939	32 631	73 044
1912	27 152	40 708	1940	34 477	72 388
1913	23 307	42 994			

[1] From 1931 on, late registrations are excluded.

[2] Births and deaths for the years 1887 to 1898 obtained from: War Department—Office Director Census of Porto Rico—Report on the Census of Porto Rico, 1899, pp. 112-113. Government Printing Office, *Washington, D. C.*
For the following years and up to the present, the information was obtained from the Reports of the Commissioner of Health to the Governor of Puerto Rico.

APPENDIX TABLE 4

Balance of immigration minus emigration, Puerto Rico, fiscal years 1908-09 to 1940-41[1]

FISCAL YEAR	NET GAIN	NET LOSS	FISCAL YEAR	NET GAIN	NET LOSS
1908-09	3 111		1925-26		5 621
1909-10	3 500		1926-27		8 729
1910-11	1 475		1927-28		6 144
1911-12	195		1928-29		4 637
1912-13	22		1929-30		5 576
1913-14		588	1930-31	1 938	
1914-15		339	1931-32	2 708	
1915-16	33		1932-33	1 082	
1916-17		2 354	1933-34	2 966	
1917-18		4 212	1934-35		1 017
1918-19		3 312	1935-36		3 448
1919-20		4 139	1936-37		4 518
1920-21	612		1937-38		2 362
1921-22	633		1938-39		4 488
1922-23		1 756	1939-40		1 904
1923-24		3 720	1940-41		988
1924-25		2 137			
			Total	18 275	71 989

[1] Source: U. S. Department of Justice, Immigration and Naturalization Service.

APPENDIX TABLE 5a

Deaths by age in Puerto Rico
All classes, calendar years 1909, 1910 and 1911[1]

AGE IN YEARS	1909	1910	1911
Under 1	5 413	6 399	6 370
1	2 340	3 232	3 314
2-4	2 102	2 967	3 179
5-9	1 083	1 331	1 314
10-14	684	763	728
15-19	855	983	991
20-24	1 276	1 430	1 421
25-29	1 248	1 396	1 423
30-39	1 826	2 042	2 220
40-49	1 504	1 596	1 813
50-59	1 247	1 398	1 432
60-69	1 069	1 257	1 294
70-79	880	968	1 080
80-89	504	624	659
90-99	168	226	245
100 and over	43	41	46
Not specified	20	21	20
All ages	22 262	26 674	27 549

[1] Obtained from the unpublished records of the Bureau of Vital Statistics of the Insular Department of Health, *San Juan, Puerto Rico.*

APPENDIX TABLE 5b

Deaths by age in Puerto Rico
All classes, January to June, July to December, 1919, 1920, and 1921[1]

AGE IN YEARS	1919		1920		1921	
	January to June	July to December	January to June	July to December	January to June	July to December
Under 1	3 237	3 595	3 839	3 992	3 794	3 977
1	1 216	1 640	1 257	1 472	1 438	1 958
2-4	1 312	1 457	1 263	1 368	1 239	1 535
5-9	893	863	704	659	676	737
10-14	485	432	372	370	397	411
15-19	664	568	578	582	568	581
20-24	1 107	816	1 031	874	856	844
25-29	836	797	851	719	798	726
30-39	1 501	1 268	1 406	1 262	1 285	1 231
40-49	1 193	1 092	1 065	1 068	952	921
50-59	1 026	890	923	898	818	843
60-69	789	790	743	663	706	766
70-79	620	617	570	540	550	536
80-89	430	436	417	432	420	304
90-99						116
100 and over						32
Not specified	—	—	—	—	—	—
All ages	15 309	15 261	15 019	14 899	14 497	15 518

[1] From the Reports of the Commissioner of Health of Puerto Rico for the fiscal years, 1918-1919, 1919-1920, 1920-1921, and 1921-1922. Bureau of Insular Affairs, U. S. War Dept. Government Printing Office, *Washington, D. C.*, 1919, 1920, and 1923.

APPENDIX TABLE 5c

Deaths by age in Puerto Rico
Males, females, and both sexes, fiscal year July 1, 1929 to June 30, 1930[1]

AGE IN YEARS	MALES	FEMALES	BOTH SEXES
Under 1	3 792	3 185	6 977
1-4	3 317	3 310	6 627
5-9	971	854	1 825
10-14	423	289	712
15-19	557	723	1 280
20-24	952	977	1 929
25-29	702	826	1 528
30-39	1 194	1 389	2 583
40-49	1 230	1 038	2 268
50-59	1 150	776	1 926
60-69	1 141	838	1 979
70-79	817	723	1 540
80-89	536	588	1 124
90-99	239	341	580
100 and over	3	—	3
Not specified	14	6	20
All ages	17 038	15 863	32 901

[1] From the Report of the Commissioner of Health of Puerto Rico for the fiscal year ending June 30, 1930, page 24. Bureau of Supplies, Printing and Transportation, *San Juan, Puerto Rico,* 1931.

APPENDIX TABLE 5d

Deaths by age in Puerto Rico
Males, females, and both sexes, calendar year 1931[1]

AGE IN YEARS	MALES	FEMALES	BOTH SEXES
Under 1	4 630	3 902	8 532
1-4	2 741	2 695	5 436
5-9	766	738	1 504
10-14	344	371	715
15-19	541	687	1 228
20-24	899	941	1 840
25-29	590	747	1 337
30-34	531	697	1 228
35-44	1 172	1 208	2 380
45-54	1 233	904	2 137
55-64	1 100	776	1 876
65-74	971	730	1 701
75 and over	1 012	1 220	2 232
All ages	16 530	15 616	32 146

[1] From the Report of the Commissioner of Health of Puerto Rico for the fiscal year ending June 30, 1932, page 46. Bureau of Supplies, Printing, and Transportation, *San Juan, Puerto Rico,* 1933.

APPENDIX TABLE 5e

Deaths by age in Puerto Rico
Males, females, and both sexes, calendar years 1934, 1935, and 1936[1]

AGE IN YEARS	MALE			FEMALE			BOTH SEXES		
	1934	1935	1936	1934	1935	1936	1934	1935	1936
Under 1	4 015	4 228	4 758	3 427	3 522	4 019	7 442	7 750	8 777
1-4	2 907	2 816	3 564	2 705	2 703	3 570	5 612	5 519	7 134
5-9	952	713	661	845	686	657	1 797	1 399	1 318
10-14	372	351	340	371	277	279	743	628	619
15-19	371	450	487	568	578	591	939	1 028	1 078
20-24	1 022	968	1 099	1 051	951	1 089	2 073	1 919	2 188
25-29	625	672	689	749	769	786	1 374	1 441	1 475
30-34	493	486	534	640	575	567	1 133	1 061	1 101
35-44	1 183	1 114	1 267	1 177	1 160	1 213	2 360	2 274	2 480
45-54	1 235	1 174	1 267	837	829	930	2 072	2 003	2 197
55-64	1 209	1 024	1 156	758	666	748	1 967	1 690	1 904
65-74	1 058	959	1 073	803	770	826	1 861	1 729	1 899
75 and over	1 098	1 091	1 176	1 232	1 221	1 442	2 330	2 312	2 618
All ages	16 540	16 046	18 071	15 163	14 707	16 717	31 703	30 753	34 788

[1] From the Reports of the Commissioner of Health of Puerto Rico for the fiscal years 1934-1935, page 64; 1935-1936, page 65, and 1936-1937, page 79. Bureau of Supplies, Printing and Transportation, *San Juan, Puerto Rico,* 1935, 1936, 1937 respectively.

APPENDIX TABLE 5f

Deaths by age in Puerto Rico
Males, females, and both sexes, calendar years 1939, 1940, and 1941[1]

AGE IN YEARS	MALE			FEMALE			BOTH SEXES		
	1939	1940	1941	1939	1940	1941	1939	1940	1941
Under 1	4 536	4 478	4 820	3 688	3 743	4 026	8 224	8 221	8 846
1-4	3 178	3 373	3 610	3 231	3 386	3 529	6 409	6 759	7 139
5-9	650	749	737	606	695	727	1 256	1 444	1 464
10-14	278	316	339	300	326	314	578	642	653
15-19	324	437	459	544	556	543	868	993	1 002
20-24	799	881	886	928	922	906	1 727	1 803	1 792
25-29	669	735	759	801	816	827	1 470	1 551	1 586
30-34	479	590	589	585	586	585	1 064	1 176	1 174
35-44	1 096	1 206	1 239	1 084	1 157	1 117	2 180	2 363	2 356
45-54	1 195	1 237	1 275	908	932	920	2 103	2 169	2 195
55-64	1 127	1 215	1 160	794	796	779	1 921	2 011	1 939
65-74	1 090	1 330	1 273	926	1 014	1 038	2 016	2 344	2 311
75 and over	1 335	1 348	1 340	1 478	1 640	1 684	2 813	2 988	3 024
Not specified	1	4	10	2	—	1	3	4	11
All ages	16 757	17 899	18 496	15 875	16 569	16 996	32 632	34 468	35 492

[1] From Vital Statistics—Special Reports: Puerto Rico, Summary of Vital Statistics, U. S. Dept. of Commerce, Bureau of the Census. 1939—Vol. 10, No. 52, p. 1533, Mar. 21, 1941. 1940—Vol. 14, No. 52, p. 1192, Feb. 9, 1942. 1941—Vol. 18, No. 53, p. 725, May 18, 1943.

APPENDIX TABLE 6

Population of Puerto Rico, by age and sex, according to the censuses of 1899 to 1940[1]

AGE IN YEARS	CENSUS DATE					
	Nov. 10, 1899	April 15, 1910	Jan. 1, 1920	April 1, 1930	Dec. 1, 1935	April 1, 1940
			Males			
Under 1	13 369[2]	20 175[2]	21 852[2]	22 252[2]	27 010[2]	30 242
1-4	63 405[2]	74 038[2]	79 046[2]	91 793[2]	97 795[2]	112 047
5-9	72 920	76 572	99 150	113 532	120 847	127 791
10-14	65 112	74 280	85 702	101 375	113 682	114 496
15-19	42 919	53 388	60 183	87 907	88 071	99 460
20-24	41 664	53 492	62 114	74 461	100 573	102 464
25-29	39 469	45 836	44 138	47 519	60 496	72 263
30-34	31 365	35 331	37 540	46 720	43 573	52 012
35-44	46 430	58 822	69 612	83 220	90 482	94 268
45-54	29 578	35 844	50 246	54 487	61 798	66 825
55-64	16 758	18 237	23 984	29 793	33 084	36 808
65-74	6 264	7 768	9 553	12 640	15 920	20 288
75 and over	2 945	3 497	4 551	5 962	8 288	8 957
Not specified	63	21	154	100	16	359
All ages	472 261	557 301	647 825	771 761	861 635	938 280

APPENDIX TABLE 6 *(continued)*

AGE IN YEARS	CENSUS DATE Nov. 10, 1899	April 15, 1910	Jan. 1, 1920	April 1, 1930	Dec. 1, 1935	April 1, 1940
			Females			
Under 1	12 940[2]	19 685[2]	21 332[2]	21 781[2]	26 442[2]	29 696
1-4	60 689[2]	71 291[2]	78 025[2]	90 642[2]	95 190[2]	108 455
5-9	70 626	74 651	95 981	110 490	118 301	123 861
10-14	59 241	69 471	82 352	97 962	111 104	112 601
15-19	50 229	60 401	66 065	98 243	94 968	106 689
20-24	46 811	55 016	66 417	74 875	104 524	103 862
25-29	44 796	48 377	51 915	52 261	64 870	75 745
30-34	32 952	35 091	40 465	47 989	45 191	50 584
35-44	45 372	57 810	68 927	81 684	90 847	92 842
45-54	29 690	34 670	41 651	48 676	54 635	59 168
55-64	16 958	19 689	21 989	26 625	29 527	33 023
65-74	6 661	9 461	10 565	13 188	16 064	21 617
75 and over	3 973	5 065	6 157	7 614	10 233	12 244
Not specified	44	33	143	122	3	588
All ages	480 982	560 711	651 984	772 152	861 899	930 975

[1] 16th Census of the United States, 1940. Puerto Rico Population—Bulletin No. 2, Characteristics of the Population, page 10. U. S. Department of Commerce, Bureau of the Census. 1943.

[2] Census of Puerto Rico, 1935. Population and Agriculture, page 23. Puerto Rico Reconstruction Administration, San Juan, Puerto Rico. U. S. Government Printing Office, *Washington, D. C.*, 1938.

APPENDIX TABLE 7

Annual births and average infant mortality rate in Puerto Rico: 1909-11, 1919-21, and 1929-31[1]

BIRTHS							
Year	Both Sexes	Year	Both Sexes	Year	Male	Female	Both Sexes
1909	37 444	1919	46 285				
1910	37 706	1920	50 416	1929-30[2]	26 889	25 509	52 398
1911	39 106	1921	51 190	1931	33 545	32 155	65 700[3]
Total	114 256	Total	147 891	Total	60 434	57 664	118 098
Annual average	38 085	Annual average	49 297	Annual average	30 217	28 832	59 049

INFANT MORTALITY RATE[4]							
1909-11	.15 913	1919-21	.15 169	1929-31	.13 936	.12 290	.13 132

[1] From the Reports of the Commissioner of Health of Puerto Rico.

[2] Fiscal year.

[3] Of the 71,210 births registered in 1931, 5510 occurred in previous years. This was due to a proviso in the new law of Birth Registration allowing for late registration in that year. As these late registered births are not distributed by sex, we assumed, in making the corrections, that they had the same sex distribution as the entire group of 71,210.

[4] Infant deaths obtained from Table 2.

APPENDIX TABLE 8

Abridged life table for Puerto Rico (all classes) — 1909 to 1911

Age interval	Population estimated as of July 1, 1910	Average annual deaths 1909-11	Average annual death rate per person	Chances per 1000 of a person age x dying within interval x to $x+n$	Number surviving to exact age x out of 100,000 born alive	Number dying in interval x to $x+n$	Life table population in interval x to $x+n$	Average years of life remaining to survivors at age x
x to $x+n$			${}_nm_x$	1000 ${}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	$\mathring{e}_x$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Under 1	39 930	6 061	.15 176	159.13	100 000	15 913	88 479	38.44
1-4	145 575	5 711	.03 923	131.58	84 087	11 064	306 109	44.66
5-9	152 145	1 243	.00 817	40.09	73 023	2 927	356 953	47.23
10-14	144 261	725	.00 503	24.86	70 096	1 743	346 521	44.11
15-19	114 051	943	.00 827	40.57	68 353	2 773	335 308	40.17
20-24	108 929	1 376	.01 263	61.35	65 580	4 023	318 527	36.75
25-29	94 252	1 356	.01 439	69.61	61 557	4 285	297 776	33.98
30-34	70 581	1 083	.01 534	74.05	57 272	4 241	276 467	31.32
35-44	117 092	1 807	.01 543	144.61	53 031	7 669	497 019	28.61
45-54	70 963	1 483	.02 090	191.43	45 362	8 684	415 502	22.50
55-64	38 095	1 280	.03 360	291.79	36 678	10 702	318 512	16.49
65-74	17 290	1 106	.06 397	489.54	25 976	12 716	198 781	11.03
75 and over	8 607	1 302	.15 127	1000.00	13 260	13 260	87 658	6.61

APPENDIX TABLE 9

Abridged life table for Puerto Rico (all classes) — 1919 to 1921

Age interval	Population estimated as of July 1, 1920	Average annual deaths 1919-21	Average annual death rate per person	Chances per 1000 of a person age x dying within interval x to $x+n$	Number surviving to exact age x out of 100,000 born alive	Number dying in interval x to $x+n$	Life table population in interval x to $x+n$	Average years of life remaining to survivors at age x
x to $x+n$			${}_nm_x$	1000 ${}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	$\mathring{e}_x$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Under 1	43 225	7 478	.17 300	151.69	100 000	15 169	89 018	38.46
1-4	158 304	5 719	.03 613	122.66	84 831	10 405	310 893	44.28
5-9	196 535	1 511	.00 769	37.78	74 426	2 811	364 292	46.30
10-14	169 574	822	.00 485	23.98	71 615	1 717	354 021	43.03
15-19	129 159	1 180	.00 914	44.75	69 898	3 128	342 232	39.02
20-24	129 542	1 843	.01 423	68.86	66 770	4 598	323 120	35.72
25-29	96 234	1 576	.01 638	78.88	62 172	4 904	299 389	33.17
30-34	78 817	1 408	.01 786	85.72	57 268	4 909	274 860	30.78
35-44	139 820	2 345	.01 677	156.29	52 359	8 183	487 955	28.41
45-54	92 445	1 933	.02 091	191.52	44 176	8 460	404 591	22.63
55-64	46 481	1 645	.03 539	305.05	35 716	10 895	307 855	16.66
65-74	20 396	1 330	.06 521	496.47	24 821	12 323	188 974	11.58
75 and over	10 847	1 378	.12 704	1000.00	12 498	12 498	98 378	7.87

APPENDIX TABLE 10a

Abridged life table for Puerto Rico (males), fiscal year July 1, 1929 to June 30, 1930, calendar year 1931

Age interval	Population estimated as of Oct. 1, 1930	Average annual deaths 1929-30, 1931	Average annual death rate per person	Chances per 1000 of a person age x dying within interval x to $x+n$	Number surviving to exact age x out of 100,000 born alive	Number dying in interval x to $x+n$	Life table population in interval x to $x+n$	Average years of life remaining to survivors at age x
x to $x+n$			${}_nm_x$	1000 ${}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	$\mathring{e}_x$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Under 1	22 651	4 211	.18 591	139.36	100 000	13 936	89 910	40.76
1-4	92 806	3 029	.03 264	112.34	86 064	9 668	317 833	46.31
5-9	114 245	868	.00 760	37.34	76 396	2 853	374 032	48.01
10-14	102 031	384	.00 376	18.64	73 543	1 371	364 628	44.79
15-19	88 485	549	.00 620	30.56	72 172	2 206	355 806	40.59
20-24	75 861	926	.01 221	59.36	69 966	4 153	340 131	36.94
25-29	48 756	646	.01 325	64.27	65 813	4 230	319 245	33.94
30-34	46 985	578	.01 230	59.79	61 583	3 682	299 350	31.08
35-44	83 772	1 180	.01 408	132.71	57 901	7 684	545 739	27.89
45-54	55 104	1 213	.02 201	200.67	50 217	10 077	457 837	21.29
55-64	30 144	1 130	.03 749	320.32	40 140	12 858	342 971	15.23
65-74	13 022	984	.07 556	551.24	27 282	15 039	199 034	9.84
75 and over	6 112	1 080	.17 670	1000.00	12 243	12 243	69 287	5.66

APPENDIX TABLE 10b

Abridged life table for Puerto Rico (females), fiscal year July 1, 1929 to June 30, 1930, calendar year 1931

Age interval	Population estimated as of Oct. 1, 1930	Average annual deaths 1929-30, 1931	Average annual death rate per person	Chances per 1000 of a person age x dying within interval x to $x+n$	Number surviving to exact age x out of 100,000 born alive	Number dying in interval x to $x+n$	Life table population in interval x to $x+n$	Average years of life remaining to survivors at age x
x to $x+n$			${}_nm_x$	1000 ${}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	$\mathring{e}_x$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Under 1	22 177	3 544	.15 980	122.90	100 000	12 290	91 102	42.19
1-4	91 533	3 002	.03 280	112.82	87 710	9 895	323 730	47.07
5-9	111 159	796	.00 716	35.22	77 815	2 740	381 443	48.89
10-14	98 694	330	.00 334	16.57	75 075	1 244	372 455	45.59
15-19	98 665	705	.00 715	35.17	73 831	2 596	363 077	41.32
20-24	76 324	959	.01 256	61.01	71 235	4 346	346 019	37.73
25-29	53 435	786	.01 471	71.11	66 889	4 756	323 317	35.00
30-34	48 119	720	.01 496	72.28	62 133	4 491	300 200	32.48
35-44	82 242	1 198	.01 457	137.04	57 642	7 899	542 141	29.80
45-54	49 201	900	.01 829	169.37	49 743	8 425	460 634	23.64
55-64	26 945	787	.02 921	258.38	41 318	10 676	365 491	17.31
65-74	13 609	762	.05 599	442.88	30 642	13 571	242 382	11.41
75 and over	7 845	1 248	.15 908	1000.00	17 071	17 071	107 311	6.29

APPENDIX TABLE 10c

Abridged life table for Puerto Rico (both sexes), fiscal year July 1, 1929 to June 30, 1930, calendar year 1931

Age interval	Population estimated as of Oct. 1, 1930	Average annual deaths 1929-30, 1931	Average annual death rate per person	Chances per 1000 of a person age x dying within interval x to $x+n$	Number surviving to exact age x out of 100,000 born alive	Number dying in interval x to $x+n$	Life table population in interval x to $x+n$	Average years of life remaining to survivors at age x
x to $x+n$			${}_nm_x$	1000 ${}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	$\mathring{e}_x$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Under 1	44 828	7 755	.17 300	131.32	100 000	13 132	90 492	41.41
1-4	184 339	6 031	.03 272	112.58	86 868	9 779	320 713	46.63
5-9	225 404	1 664	.00 738	36.28	77 089	2 797	377 654	48.38
10-14	200 725	714	.00 356	17.65	74 292	1 311	368 258	45.12
15-19	187 150	1 254	.00 670	32.99	72 981	2 407	359 254	40.89
20-24	152 185	1 885	.01 239	60.21	70 574	4 249	342 938	37.19
25-29	102 191	1 432	.01 401	67.84	66 325	4 499	321 128	34.40
30-34	95 104	1 298	.01 365	66.15	61 826	4 089	299 560	31.71
35-44	166 014	2 378	.01 432	134.83	57 737	7 785	543 645	28.77
45-54	104 305	2 113	.02 026	186.07	49 952	9 294	458 736	22.37
55-64	57 089	1 917	.03 358	291.65	40 658	11 858	353 127	16.20
65-74	26 631	1 746	.06 556	498.41	28 800	14 354	218 944	10.61
75 and over	13 957	2 328	.16 680	1000.00	14 446	14 446	86 607	6.00

APPENDIX TABLE 11a

Abridged life table for Puerto Rico (males) — 1934 to 1936

Age interval	Population estimated as of July 1, 1935	Average annual deaths 1934-36	Average annual death rate per person	Chances per 1000 of a person age x dying within interval x to $x+n$	Number surviving to exact age x out of 100,000 born alive	Number dying in interval x to $x+n$	Life table population in interval x to $x+n$	Average years of life remaining to survivors at age x
x to $x+n$			${}_nm_x$	$1000\ {}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	$\mathring{e}_x$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Under 1	26 648	4 334	.16 264	131.14	100 000	13 114	90 505	43.12
1-4	97 339	3 096	.03 181	109.84	86 886	9 544	321 438	48.58
5-9	120 291	775	.00 644	31.73	77 342	2 454	379 867	50.42
10-14	122 747	354	.00 314	15.59	74 888	1 167	371 656	47.00
15-19	88 059	436	.00 495	24.47	73 721	1 804	364 444	42.71
20-24	98 588	1 030	.01 045	51.01	71 917	3 668	351 005	38.71
25-29	59 510	662	.01 112	54.20	68 249	3 699	332 644	35.65
30-34	43 812	504	.01 150	56.00	64 550	3 615	314 348	32.54
35-44	89 930	1 188	.01 321	124.96	60 935	7 615	576 457	29.31
45-54	61 242	1 225	.02 000	183.89	53 320	9 805	490 250	22.68
55-64	32 834	1 130	.03 442	297.89	43 515	12 963	376 612	16.53
65-74	15 671	1 030	.06 573	499.35	30 552	12 256	232 101	11.22
75 and over	8 111	1 122	.13 833	1000.00	15 296	15 296	110 576	7.23

APPENDIX TABLE 11b

Abridged life table for Puerto Rico (females) — 1934 to 1936

Age interval	Population estimated as of July 1, 1935	Average annual deaths 1934-36	Average annual death rate per person	Chances per 1000 of a person age x dying within interval x to $x+n$	Number surviving to exact age x out of 100,000 born alive	Number dying in interval x to $x+n$	Life table population in interval x to $x+n$	Average years of life remaining to survivors at age x
x to $x+n$			${}_nm_x$	1000 ${}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	$\mathring{e}_x$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Under 1	26 088	3 656	.14 014	115.61	100 000	11 561	91 630	45.11
1-4	94 844	2 993	.03 156	109.08	88 439	9 647	327 311	49.98
5-9	117 707	729	.00 619	30.51	78 792	2 404	387 259	51.94
10-14	110 105	309	.00 281	13.96	76 388	1 066	379 359	48.50
15-19	95 217	579	.00 608	29.98	75 322	2 258	371 382	44.16
20-24	102 271	1 030	.01 007	49.20	73 064	3 595	357 001	40.44
25-29	63 912	768	.01 202	58.47	69 469	4 062	337 937	37.39
30-34	45 404	594	.01 308	63.47	65 407	4 151	317 355	34.55
35-44	90 151	1 183	.01 312	124.16	61 256	7 606	579 726	31.71
45-54	54 182	865	.01 596	149.25	53 650	8 007	501 692	25.40
55-64	29 306	724	.02 470	222.66	45 643	10 163	411 457	18.86
65-74	15 845	800	.05 049	408.61	35 480	14 498	287 146	12.66
75 and over	10 034	1 298	.12 936	1000.00	20 982	20 982	162 198	7.73

APPENDIX TABLE IIc

Abridged life table for Puerto Rico (both sexes)—1934 to 1936

Age interval	Population estimated as of July 1, 1935	Average annual deaths 1934-36	Average annual death rate per person	Chances per 1000 of a person age x dying within interval x to $x+n$	Number surviving to exact age x out of 100,000 born alive	Number dying in interval x to $x+n$	Life table population in interval x to $x+n$	Average years of life remaining to survivors at age x
x to $x+n$			${}_nm_x$	1000 ${}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	$\mathring{e}_x$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Under 1	52 736	7 990	.15 150	123.55	100 000	12 355	91 055	44.03
1-4	192 183	6 089	.03 168	109.45	87 645	9 592	324 315	49.20
5-9	237 998	1 504	.00 632	31.14	78 053	2 431	383 487	51.09
10-14	222 852	663	.00 298	14.80	75 622	1 119	375 503	47.66
15-19	183 276	1 015	.00 554	27.35	74 503	2 037	367 690	43.34
20-24	200 859	2 060	.01 026	50.10	72 466	3 631	353 899	39.48
25-29	123 422	1 430	.01 159	56.43	68 835	3 884	335 116	36.42
30-34	89 216	1 098	.01 231	59.83	64 951	3 886	315 678	33.44
35-44	180 081	2 371	.01 317	124.61	61 065	7 609	577 752	30.40
45-54	115 424	2 090	.01 811	167.83	53 456	8 972	495 417	23.92
55-64	62 140	1 854	.02 984	263.26	44 484	11 711	392 460	17.61
65-74	31 516	1 830	.05 806	455.33	32 773	14 922	257 010	11.93
75 and over	18 145	2 420	.13 337	1000.00	17 851	17 851	133 846	7.50

APPENDIX TABLE 12a

Abridged life table for Puerto Rico (males) — 1939 to 1941

Age interval	Population estimated as of July 1, 1940	Average annual deaths 1939-41	Average death rate per person	Chances per 1000 of a person age x dying within interval x to $x+n$	Number surviving to exact age x out of 100,000 born alive	Number dying in interval x to $x+n$	Life table population in interval x to $x+n$	Average years of life remaining to survivors at age x
x to $x+n$			${}_nm_x$	1000 ${}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	$\mathring{e}_x$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Under 1	30 441	4 611	.15 147	123.53	100 000	12 352	91 057	45.12
1-4	112 551	3 387	.03 009	104.61	87 648	9 169	325 504	50.44
5-9	128 146	712	.00 556	27.45	78 479	2 154	386 383	52.19
10-14	114 823	311	.00 271	13.46	76 325	1 028	379 336	48.60
15-19	99 748	407	.00 408	20.21	75 297	1 522	373 039	44.23
20-24	103 161	855	.00 829	40.67	73 775	3 000	361 882	40.08
25-29	72 879	721	.00 989	48.34	70 775	3 421	345 905	36.67
30-34	52 144	553	.01 060	51.72	67 354	3 484	328 679	33.40
35-44	94 543	1 180	.01 248	118.51	63 870	7 569	606 490	30.07
45-54	67 132	1 236	.01 841	170.39	56 301	9 593	521 076	23.34
55-65	36 983	1 167	.03 156	276.43	46 708	12 911	409 094	16.98
65-74	20 478	1 231	.06 011	467.41	33 797	15 797	262 802	11.36
75 and over	9 032	1 341	.14 847	1000.00	18 000	18 000	121 237	6.74

APPENDIX TABLE 12b

Abridged life table for Puerto Rico (females) — 1939 to 1941

Age interval	Population estimated as of July 1, 1940	Average annual deaths 1939-41	Average annual death rate per person	Chances per 1000 of a person age x dying within interval x to $x+n$	Number surviving to exact age x out of 100,000 born alive	Number dying in interval x to $x+n$	Life table population in interval x to $x+n$	Average years of life remaining to survivors at age x
x to $x+n$			${}_nm_x$	1000 ${}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	$\mathring{e}_x$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Under 1	29 893	3 819	.12 776	106.74	100 000	10 674	92 272	46.92
1-4	108 899	3 382	.03 106	107.57	89 326	9 609	330 935	51.50
5-9	124 194	676	.00 544	26.86	79 717	2 141	392 613	53.55
10-14	112 965	313	.00 277	13.76	77 576	1 067	385 198	49.97
15-19	106 900	547	.00 512	25.30	76 509	1 936	378 125	45.63
20-24	104 584	919	.00 879	43.07	74 573	3 212	365 415	41.75
25-29	76 330	815	.01 068	52.11	71 361	3 718	348 127	38.50
30-34	50 649	585	.01 155	56.24	67 643	3 804	329 351	35.48
35-44	93 119	1 119	.01 202	114.28	63 839	7 296	606 988	32.43
45-54	59 429	920	.01 548	145.05	56 543	8 201	529 780	25.88
55-64	33 182	790	.02 381	215.44	48 342	10 415	437 421	19.31
65-74	21 827	993	.04 549	375.90	37 927	14 257	313 410	13.08
75 and over	12 359	1 601	.12 954	1000.00	23 670	23 670	182 723	7.72

APPENDIX TABLE 12c

Abridged life table for Puerto Rico (both sexes)—1939 to 1941

Age interval	Population estimated as of July 1, 1940	Average annual deaths 1939-41	Average annual death rate per person	Chances per 1000 of a person age x dying within interval x to $x+n$	Number surviving to exact age x out of 100,000 born alive	Number dying in interval x to $x+n$	Life table population in interval x to $x+n$	Average years of life remaining to survivors at age x
x to $x+n$			${}_nm_x$	1000 ${}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	$\mathring{e}_x$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Under 1	60 334	8 430	.13 972	115.32	100 000	11 532	91 651	45.96
1-4	221 450	6 769	.03 057	106.08	88 468	9 384	328 158	50.92
5-9	252 340	1 388	.00 550	27.15	79 084	2 147	389 429	52.81
10-14	227 788	624	.00 274	13.61	76 937	1 047	382 117	49.22
15-19	206 647	954	.00 462	22.85	75 890	1 734	375 325	44.86
20-24	207 745	1 774	.00 854	41.87	74 156	3 105	363 583	40.85
24-29	149 209	1 536	.01 029	50.25	71 051	3 570	346 939	37.52
30-34	102 793	1 138	,01 107	53.96	67 481	3 641	328 907	34.36
35-44	187 663	2 299	.01 225	116.35	63 840	7 428	606 367	31.17
45-54	126 561	2 156	.01 704	158.63	56 412	8 949	525 176	24.53
55-64	70 165	1 957	.02 789	248.08	47 463	11 774	422 158	18.09
65-74	42 305	2 224	.05 257	421.78	35 689	15 052	286 323	12.23
75 and over	21 391	2 942	.13 753	1000.00	20 636	20 636	150 047	7.27